into its present position. We were now at the summit of the hill; and, as the too short day faded into twilight, we looked up the 'reach' of the valley of the Ceiriog, which stretches from the New Inn to Pontymeibon, and could distinctly trace on the surface the rugged escarpments of the three 'Ash-beds' and the three Limestones, with the depressions between each, which serve to mark the place of the softer intervening Shales. This order of the strata may be taken as a type of this portion of the Bala or Llandeilo Group as it is developed in North Wales. In South Wales, where the Bala Limestone loses its distinctive features, the Trap-rocks also lose their massiveness; and the same is the case at Shelve, where the Ash-beds occur in numerous layers interstratified with flags and shales. We noticed the correspondence which each side of the valley bears to the other, Ash-bed, Limestone, and Shale answering each to each on either side, like Coleridge's 'Roland and Sir Leoline.'

> They stand aloof, the scars remaining.
> * * * * *
> Like cliffs which have been rent asunder;
> But neither time nor frost nor thunder
> Will wholly do away, I ween,
> The marks of that which once hath been.

This is not a mere valley of erosion; for in the dipping of the strata on the one side to the NE., and on the other to the SE., we at once perceive that it owes its origin to a crack in continuous strata, made in the process of upheaval, the said crack having been since widened by time and action of water, which weareth away the stones.

The day was closing, so we descended rapidly, past the kilns where the stone is burnt for lime, past the Shales overlying the Limestone, past the third or Hirnant Limestone, and, recruiting our strength at the New Inn, heavily ballasted with fossils, we wended our way up the steep hills of 'Wenlock Shale' which divide the valleys of the Ceiriog and the Dee. The lights of the town of Llangollen peered through the gloom as we gained the summit, and before long we were there. And now, kind reader, having brought you safely to a habitable and hospitable place, we thank you for your company, and bid you good-night.

ABSTRACTS OF BRITISH AND FOREIGN MEMOIRS.

[The Report of this and the following Paper, read before the British Association at Bath, Sept. 1864, has been unavoidably postponed until this month.]

1. On the Boulder-clay of East Yorkshire. By J. Leckenby, F.G.S.

THE author pointed out the existence of the evidence of glacial conditions in the clays, sands, and gravels which overlie the Secondary strata of Yorkshire in its northern and eastern portions, especially around Whitby and Scarborough, in the Moorland Valleys, in the neighbourhood of Thirsk, and in the New Red Sandstone district near Ripon.

At Scarborough two well-marked divisions of these deposits were shown to obtain; the lower consisting of rolled and often firmly compacted gravels, in which were found fragments of the various granites of Scotland and Westmoreland, and of the hard blue Carboniferous Limestones of West Yorkshire. Blocks of granite of large size were not uncommonly found presenting scratched and grooved surfaces; but, probably owing to the softer nature of the Secondary strata of Yorkshire, no grooving or polishing of these rock-surfaces could be found.

Intercalated with these gravels are irregular beds of sand; and the whole are so arranged as to preclude the possibility of referring them to merely aqueous agency; the lines of demarcation being sharply defined, and the beds exhibiting distinct angles over which other materials are assorted.

The author described the upper division as composed of uniformly compact clay, with occasional seams of pure sand, well exhibited towards the northern point of Filey Bay near Scarborough, where numerous granite boulders with glacial markings existed *in sitû*.

The entire thickness of the beds at Scarborough was stated to be not less than 200 feet, which was probably their maximum development.

The author collected the following shells in these glacial beds at Scarborough:—

Mytilus edulis.
Cyprina Islandica.
Venus lincta.
Astarte borealis.
Tellina Balthica.
T. calcarea.
Mya truncata, *var.* Uddevallensis.

Mr. J. Gwyn Jeffreys collected in the Boulder-clay at Whitby, besides those above numerated, the following:—

Astarte sulcata, *var.* elliptica.
Cardium edule.
Pholas crispata.
Balanus porcatus.
B. crenatus.
Lepralia.

Alluding to the absence of univalves, the smaller number of bivalves, and their more fragmentary characters, Mr. Leckenby pointed out the difference, in these respects, from the Caithness beds described by Mr. Peach before the Association in 1862, but which, from Mr. Peach's description, resembled in general features those of Yorkshire.

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2. On Changes of the Relative Level of Land and Sea in South-eastern Devonshire, in connection with the Antiquity of Man.

By W. Pengelly, Esq., F.R.S., F.G.S.

FROM a careful examination of the geological evidences that can be studied relative to changes of level in Devonshire, Mr. Pengelly was led to recognize the following periods of change and their several results:—1st. A remote period prior to the lodgement of the gravels now occupying the valley-slopes and summits of the

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lesser hills of South-eastern Devonshire. In all other respects the physical characters of the district were as at present.—2nd. This was followed by a subsidence, the entire area ultimately becoming at least 300 feet lower than now. During this depression, marine gravels—not entirely of immediate, but never of very remote derivation—accumulated in the valleys until they were entirely obliterated; the summits of the hills were also covered, and similar materials were lodged in such fissures and crevices as traversed the rocks. Dartmoor existed as an archipelago, and was probably inhabited by the Dwarf-birch and Willows suitable to the Arctic or Sub-arctic climate which then prevailed.—3rd. A slow and uniform upheaval then brought up the entire district until it was no more than about 200 feet lower than at present. During this movement very much of the gravels previously deposited were stripped off.—4th. At this point the upward movement was intermitted, and no further change of relative level occurred for a very prolonged period. During this interval the breakers, by grinding down the outcrops of hard inclined beds of limestone, produced the extensive horizontal platforms of the Torbay district.—5th. To this succeeded a resumption of the slow and uniform elevatory movement. The limestone-terraces first emerged into dry land; the gravels were wholly or partially swept out of the valleys, but possibly, and at least in some cases probably, still more slowly than the district rose; small patches of it were left, or perhaps re-deposited, here and there, on the hill-slopes as they rose above the sea-levél, as, for example, on Windmill and Parkham Hills at Brixham, about 50 feet below the terraces just mentioned. Bovey Plain and the Brixham Cavern, each 50 feet lower still, at length became sub-aërial, and gradually the total elevation of the land produced by this second upheaval amounted to about 125 feet. *Betula nana* and the *Salices* probably took possession of the occasionally flooded Bovey Plain as soon as it was ready for their reception, which could not have been earlier than towards the close of this period; but the land was not yet high enough for the fluviatile introduction of the bone-bed of the cavern.—6th. Again the upward movement was suspended for a long time, and, during the pause, the breakers planed down the terrace represented by the Roundham-head Level.—7th. This achieved, the district once more began to rise, and when the Brixham Cavern had reached an elevation of not less than 40 feet above the sea, its bone-bed, with the multifarious articles found in it in 1858, might have been carried in; but, though it is apparently impossible to assign this event to an earlier period, there seems nothing to prevent its having belonged to a considerably later one. Whenever it took place, however, the bottoms of the adjacent valleys—whether of undisturbed gravel or of limestone rock—were not below the cavern-level; and at this height they must have remained during the very prolonged period represented by the deposit in question. This upheaval increased the elevation of the land by about 45 feet, or, in other words brought it up to within 30 feet of its present height.—8th. Once more the emergence was suspended, and in the pause were produced the well-known Raised Beaches. This period, however, distinctly divides itself into three: first, or earliest, that in which the waves cut, in the semi-crystalline limestone and almost vertical beds of the harder kinds of slate, a series of approximately horizontal shelves, some of which, notwithstanding their subsequent waste, are still upwards of 60 feet broad; secondly, that of the accumulation of the Beaches, which are made up of beds of gravel, succeeded at the higher levels by layers of fine sand, and in some cases terminated by what appears to be blown sand; and, thirdly, that in which the Beaches themselves were cut back into cliffs and shorn of much of their dimensions.—9th. Again the upward movement was resumed, and the entire district raised to an elevation of at least 40 feet greater than at present. Whether or not this was followed by an intermittence, there is no evidence to show; nor is it possible to say how long was the time before the newly emerged district was occupied with large trees. It is certain that during a vast period, either of rest or of continued elevation, it was covered with a forest, in which the Ox, Red-deer, Boar, Horse, and Mammoth found food and shelter, and the débris of which furnished them with graves.—10th. From the analogy furnished by the preceding phenomena, it seems highly improbable that an upward movement would be exchanged for a downward one without an intermediate pause. On this point, however, there appears to be no direct evidence. All that can be affirmed positively is, that after the Forest-era the entire district was carried down from whatever had been its previous height until the base of the forest-ground was not less than 40 feet below the sea-level.—11th. Assuming that the subsidence just mentioned was the last movement the district has experienced, we are in possession of facts pointing to the conclusion that the commencement of the period of quiescence which followed dates far back from the present day, down to which it has continued. No sooner have the sea and land acquired a new relative level than the former attacks the latter and produces a new line of cliffs with their concomitant platforms. Whatever was the maximum elevation obtained by the forest-area, an addition to that amount must be made to the existing heights of all the higher level-deposits: thus, for example, if the whole of Torbay to or beyond the five-fathom line was then dry land, the Raised Beaches, instead of 30, must have been 70 feet above the sea-level, and so on in all the other cases. As the works of Man remain in the Brixham Cave, which received its present contents at the time of the second upheaval, alluded to above, the human inhabitants of the area in question witnessed an Arctic flora in Devonshire, saw engulfed rivers carry into caverns osseous deposits, and, in times much less ancient, they may have collected Shell-fish on the old sea-beaches, now 30 feet above the reach of the highest tide, and hunted the Mammoth in a forest over which our largest ships of war now ride at anchor.

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3. Les Eaux minérales du Massif central de la France, considérées dans leur rapports avec la Chimie et la Géologie. Par Henri Lecoq, Professeur à la Faculté des Sciences de Clermont, &c. Paris, 1864. Pp. 352.—(The Mineral Springs of the Central Plateau of France.)

THIS volume is a sequel to Professor Lecoq's general work on mineral springs, very recently published and already noticed in these pages.* It is an application of the principles there enunciated to the case of Central France, and is the first instalment of a work in preparation by its author on the geological epochs of Auvergne.

In the classification of the mineral waters of France, M. Lecoq, following M. Deville, adopts a mixed geographical and chemical division into five groups, each characterized by the presence of a class of salts. These groups are as follows:—1st. The waters of the Central Plateau of France, where the *bicarbonates* are present in the proportion of 75 per cent. These waters contain upwards of 300 grains of solid matter to the gallon.—2nd. The mineral springs of the Alps and Corsica, characterized by *sulphates* in the proportion of about 43 per cent., but not containing more than 170 grains to the gallon.—3rd. The springs of the Vosges, the Jura, and the hills of the Upper Saône. These contain 67 per cent. of *chlorides*, and 240 grains to the gallon.—4th. Those of the Ardennes and Hainault, characterized both by *bicarbonates* and *chlorides*. The first are in the ratio of 49 per cent., and the others 43. The solids are about 105 grains per gallon.—5th. The springs of the North-west Plateau, or Brittany, containing about 30 per cent. of *sulphates*, 38 per cent. of *bicarbonates*, and 23 per cent. of *chlorides*; but the whole solid contents are not more than 40 grains per gallon.

Locally M. Lecoq establishes fifteen groups of springs—seven in the department of Puy-de-Dôme, the rest in adjacent departments. The former are the more generally known, and the more interesting in a geological sense. Of its seven groups, that of Mont Dore is the first considered. Mont Dore consists of a mass of volcanic rock, nearly 3,000 feet thick in places, and situated on a granitic plateau.* Fissures have been formed in this erupted mass after cooling dislocations have taken place, and mineral springs rise in the long valleys of Mont Dore and Chaudefour, radiating from the centre of the mountain-group. In the Mont-Dore Valley (Dordogne) are several groups issuing from trachyte. In the Chaudefour they are from crevices in the granite.

In the upper part of the valley of the Dordogne is the spring called *la Cheminée du Diable* (the Devil's Chimney). It is situated at the foot of the Pic de Sancy, and is not very accessible. It is singular to see a deposit of iron and limestone amidst trachyte. The minerals have been left behind by the spring, which is now small and cold. M. Lecoq believes that the carbonate of lime comes in this case from beneath the granite underlying the trachyte. Several adjacent springs are ferruginous.

The *Mont-Dore* springs may be regarded as seven in number, but each includes a small group. Their temperature varies from 108°

* See Geol. Mag., Vol. II. pp. 115 and 164.

† The highest point of the Pic de Sancy is 6,130 feet above the sea.

F. to 113° F. Some yield very small quantities of water, and their total yield is about 48 gallons per minute. The water issues clear, and slightly acidulous, and becomes cloudy on exposure to the air. Carbonic acid gas is emitted with the water, the quantity varying with the weather and in the different springs. One spring much colder than the rest yields a much larger quantity of gas than the others. Nitrogen and a little oxygen are also given off. The composition of the waters is very complex, including bicarbonate of soda, potash, lime, lithia, magnesia, manganese, protoxide of iron, rubidium, and cæsium;* chloride, iodide, and fluoride of sodium; sulphate, arseniate, and borate of soda; silica, alumina, and a trace of bituminous organic matter.

M. Lecoq, with good reason, attaches much importance to the mineral deposits in the neighbourhood of springs. In those of Mont Dore he finds traces of iodine; and Berthier has alluded to phosphorus and fluorine. A considerable mass of resinous quartz was destroyed in building the thermal establishment. It contained silicified wood. It is thought that the quantity of silica in the water diminishes.

A tufaceous deposit on the banks of the Dordogne, about $1\frac{1}{4}$ mile below Mont Dore, marks the springs of the *Compissade.* They are three in number, issuing from trachyte, and flowing over travertin. Two are cold, and one is warm, the latter depositing silica. About $2\frac{3}{4}$ miles beyond, out of fissures in granite and trachytic tufa, rise the springs of *La Bourboule.* They are seven in number, yielding about six gallons per minute, the temperature high but variable, sometimes nearly 130° F. They yield chiefly common salt and bicarbonate of soda. They also show traces of the chlorides of lithium and the new metals, phosphate and arseniate of soda, iodide and bromide of sodium. A slight odour of sulphuretted hydrogen is noticed at the springs, and they have a distinctly acid and salt taste.

In the valley of Chaudefour are a number of small mineral springs, some warm and some cold. They are for the most part chalybeate. They yield, on the whole, about 60 gallons per minute. The new metals have not been detected in them; but they contain iodine, bromine, arsenic, phosphorus, and a calculable percentage of sulphate of strontia. All yield carbonic acid gas. A large deposit of carbonate of lime is obtained from the waters of St. Nectaire, and advantage is taken of this in the manufacture of natural cameos resembling those of Tuscany.

In traversing the granite, these mineral waters change and decompose the felspar, and cause the rock to disintegrate, while occasionally crystals of arragonite are deposited in the crevices and fissures of the rock.

The second division of the mineral springs of the district includes a number of outlying groups. Of those on the banks of the Allier, one (*Saut du Loup*) is intermittent; others (*Nonette, Coudes*) rise through large masses of travertin; another (*Tambour*, the Drum) issues with a rumbling noise; others (*St. Mar-*

* It is from the mother-water derived from evaporating 200 litres (17 gallons) of water, that these metals and lithia have been determined.

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guerite) are warm (90° F.), and contain much carbonate of lime, with bicarbonate of soda, common salt, and various other salts, to the extent of 600 grains to the gallon. One of the number (*St. Martial*) yields as much as 470 grains of salt to the gallon, and rises through a mass of travertin 2,000 feet in diameter, and nearly 7 feet thick. More than one human skeleton has been found in this mass. This is the more remarkable, as these waters now deposit but little carbonate of lime. The celebrated springs of Vichy belong to this group. They are situated in an alluvial basin in Tertiary deposits of small thickness, resting on Primary rocks. The whole is permeated by the mineral waters which probably issue from the granite. Springs have been obtained from artificial borings, in addition to those that rise from natural crevices. There are now thirteen natural springs and three borings. The temperature is exceedingly variable (from 54° to 111° F.). The volume of water issuing is also variable, but the total is not estimated at more than 65 gallons per minute. Some of the springs are intermittent. Carbonic acid gas issues from the water of some of the springs with great violence, but this is somewhat marked by a peculiar and rather bituminous odour derived from organic matter. Nearly 500 grains of carbonic acid by weight are contained in a gallon of Vichy water from some of the springs, and about 300 grains of solid bases. Of free carbonic acid gas there are from 70 to 200 grains per gallon. There are bicarbonates of soda (in large quantity), potash, magnesia, strontian, lime, protoxide of iron, and protoxide of manganese ; sulphate, phosphate, arseniate and borate of soda ; chloride of sodium, and silica. Traces of lithia, iodine, and bromine have also been recognized. The quantity of carbonic acid issuing from these waters of Vichy is so large, as to suggest to M. Lecoq the presence of large deposits of carbon or of solid carbonic acid in the interior of the earth. The albuminous matter present is also very remarkable, as it presents analogies with the vegetable kingdom in its green colour, and with the animal kingdom in its nature. On exposure it becomes fetid, but does not yield animalcules. The quantity of soluble bicarbonate of soda that issues from the Vichy springs and runs away into the Allier, and so to the ocean, amounts to nearly 1,400 tons per annum. The quantity of insoluble matter is much smaller (amounting to about 100 tons per annum). This has formed a deposit in the Vichy basin estimated to amount to not less than 3,000,000 tons. At the present rate of deposit, it would take upwards of 30,000 years to form such a mass. This is a long period for contemporary deposits. All the Vichy waters, however, tend to choke up their outlets, and the issue of the water may formerly have been much larger than it is now.

Near Clermont are some remarkable springs. Those of Royat, three in number, pass through Tertiary sandstones and travertins. Their temperature varies from 86° to 95° F. They yield much nitrogen. They contain chiefly the bicarbonates of soda, lime, magnesia, and potash, and common salt, but also sulphate, phosphate, and arseniate of soda, and chloride, iodide, and bromide of sodium.

The deposits choking up the issue of the water are very extensive, and of great thickness.

Most of the Clermont springs rise to the west and north-west of the town. They are sixteen in number, and compose four groups. Some are artificial borings. One group—that of St. Alyr—is remarkable for the beautiful incrustations produced by its waters. All have deposited enormous quantities of travertin. A natural bridge and aqueduct of travertin, nearly 300 feet in total length and 16 feet wide, is an interesting example of the nature of this deposit. It has been about four centuries in forming. The St. Alyr deposits are interesting in a mineralogical sense, owing partly to their condition, and partly to the banded structure of the carbonate of lime, more or less coloured by iron oxide. There is also a curious rock, consisting of a very hard conglomerate with a calcareous cement, combining an infinity of minute water-worn grains and pebbles of quartz, pozzuolana, fragments of basalt, and scoriæ. The composition of the older travertin seems different from that of the modern deposits. The former yields the following analysis:—

Water	0·800
Carbonate of lime	40·224
Carbonate of magnesia	26·860
Carbonate of strontian	0·043
Peroxide of iron	6·200
Sulphate of lime	5·382
Sub-phosphate of alumina	4·096
Phosphate of manganese	0·400
Crenate and apocrenate of iron	5·000
Organic matter not nitrogenized	1·200
Silica	9·780
Loss	0·015
	100·000

The more modern rock gives only a trace of carbonate of strontia, 32 per cent. of carbonate of lime, and 9 per cent. of sulphate of lime.

Besides these there are many other springs in the valley of the Limagne, generally issuing from minute transverse fissures in the granite. The total quantity of water is large, but most of the separate springs are very small. Arsenic has been detected in them. Bromine and iodine, phosphorus and strontian, have also been found. There are considerable masses of travertin in their immediate vicinity.

On the banks of the Sioule there are numerous groups of springs, of which those of Châteauneuf are the most important. Some are cold, and several are warm. Neutral bicarbonates are the chief contents. The waters being immediately mixed with those of the river, there is no opportunity of forming deposits.

A number of other springs are described by M. Lecoq in various parts of the Puy-de-Dôme. Some few are sulphurous, but most of them yield large quantities of carbonic acid gas and sub-carbonates. The *Puy de la Poix* yields a considerable quantity of bitumen, especially in winter. It is estimated that at least 150 kilomètres of this substance is thrown out with the water every year, and being indestructible, it accumulates in little hillocks. It has been remarked that bitumen is common in the schists of Auvergne.

In the department of Cantal there are no less than 103 mineral springs, 83 issuing from granite and other crystalline metamorphic rocks, and 16 from volcanic rocks. They chiefly emerge in valleys. Of some of these the temperature is very high, but not constant. The Chaudesaigues springs, for example, not only vary from time to time, but seem permanently hotter now than formerly. The spring of *Par* in 1771 was described as having a temperature of 167° F.; and in 1828, 177½ F. Others are lower, but all are very hot. The quantity of water issuing is large, and the whole neighbourhood around feels the effect. The hot water is used for various economical purposes, amongst others for warming the houses. It is calculated that the quantity of heat liberated each day by these waters is equivalent to the consumption of about six tons of coal. Although so hot, the waters of Chaudesaigues are not rich in salts and other minerals.

While the springs of *Par* have increased in temperature since 1788, those of *Néris* on the Allier have greatly cooled. The spring *Grand-Puits* has lowered from 172° F. to 126½ F., and the *Puits de la Croix* from 167° F. to 125° F.; the lowering not having been gradual, but by jumps. The great earthquake of Lisbon (1775) produced very marked effects on this spring. In solid contents the Neris water is not remarkable, but it is unusually rich in organic matter, and a peculiar growth of *Confervæ* takes place very rapidly after the water reaches the surface.

We have given this very brief abstract of the contents of M. Lecoq's very elaborate volume, in order that our readers may form some notion of the extent of material accumulated. Nearly 300 springs are described, and some account given of each, including in most cases the volume of water, the temperature, and the contents as determined by analysis. It would be unfair not to recognize the great labour and care that have been taken, though one would have been glad of some general *résumé* rendering the facts more generally manageable. M. Lecoq bears constantly in mind his theory of the origin of mineral springs; but this does not prevent him from putting forward honestly the whole of the evidence that exists in the case of the springs he professes to describe. His work must always be valuable as a book of reference.—D. T. A.

REVIEWS.

1. The Water-supply of the Permian Rocks of Durham.*

On the Magnesian Limestone of Durham. By Messrs. Daglish and Forster. *British Assoc. Report, 1863, p. 726.*

Water-supply.—The hydrology of the Magnesian Limestone and the Red Sandstone beneath it is first discussed; and there are

* See Geological Magazine, Vol. II. p. 29.